ANÆSTHETIC AGENTS.

69. *Death from Chloroform—Means to be employed to prevent a fatal effect from an over-dose.*—Dr. Snow read to the Westminster Medical Society, March 31st, a paper on the fatal cases of inhalation of chloroform. He said that, soon after the inhalation of ether was introduced, it was reported to have caused death in two or three cases; but, as the effects of ether became better known to the profession, it became evident that these deaths, which occurred three or four days after severe operations, could not be attributed to the inhalation. Chloroform was much more powerful than ether; the quantity of it required to induce insensibility was less than one-tenth as much by measure as in the case of ether. Viewed in this manner, it was more than ten times as strong; but to ascertain their comparative physiological power, when inhaled in a similar manner, their respective volatility requires to be taken into account. If a patient breathed air saturated with vapour of chloroform at 60°, twelve ordinary inspirations of twenty-five cubic inches each would suffice to produce the usual amount of insensibility required in a surgical operation, but it would require thirty-two similar inspirations of air saturated with vapour of ether, at the same temperature, to produce a like effect; therefore chloroform was nearly three times as strong as ether when inhaled in the same way, and this was one of the chief causes of the accidents which had happened. When an animal was allowed to continue breathing air charged with vapour of chloroform, after it had become completely insensible, the respiration shortly ceased; but if the air did not contain more than about five per cent. of the vapour, the heart continued to pulsate for some little time after the respiration had ceased, and the circulation was finally arrested for want of the respiration, as in all other cases when death took place by apnœa. During the interval that the heart continued to beat, the animals were easily resuscitated by artificial respiration. When, however, an animal was made to breathe air containing a greater quantity of vapour—ten per cent., or upwards—death took place in from half a minute to two minutes, and the respiration and circulation ceased about the same time; the reason of this was, that there was sufficient vapour in the lungs, at the moment the breathing stopped, to paralyze the heart as soon as it was absorbed and added to that already in the blood. Under these circumstances, it was evident that artificial respiration could be of no avail, and there was every reason to believe that this was the condition of the patients in the greater part of the fatal cases of inhalation of chloroform. To gain a clear idea of the cause of these accidents, it was necessary to consider the quantity of chloroform in the blood and in the lungs under different circumstances. Thirty-six minims was the average quantity required to be inhaled, to induce insensibility in the adult, but only about half of this was absorbed, the remainder being expired again. He had previously related some experiments undertaken to ascertain the exact proportion of chloroform in the blood in the different degrees of narcotism, by which it was shown that about twelve minims was the quantity in the second degree—the stage in which the mind wandered and voluntary motion was unsteady; about eighteen minims in the third degree—the usual stage in which operations were performed; about twenty-four minims in the fourth degree—the stage of complete insensibility with relaxation; a little more than thirty minims, the quantity that would be required to suspend respiration; and thirty-six or thirty-seven minims to arrest the action of the heart. The quantity of air usually present in the lungs was about 250 cubic inches. If a patient were breathing air saturated with chloroform at 60°, this quantity of air would contain thirty minims before it entered the lungs; but as absorption and inhalation went on together, probably only from fifteen to twenty minims would be present in the lungs at one time during ordinary respiration, and if the chloroform were removed from the patient's mouth, part of this would be expired again, and not more than ten to fifteen minims would be absorbed into the blood after the discontinuance of the inhalation; but this, if the patient were already insensible, might so increase the narcotism as to lead to a fatal result. The time during which the narcotism might continue to increase after the inhalation was discontinued, owing to the

absorption of the vapour remaining in the lungs, was about twenty seconds, as he had stated on a former occasion. These considerations would make it evident, that, unless some systematic means were taken for having the vapour largely diluted with air, so that its effects might be gradually induced in not less time than about two minutes—and no great quantity of chloroform could ever be present in the lungs at one time—fatal accidents would be liable to occur. Unfortunately, Dr. Simpson, to whom they were indebted for the introduction of chloroform, recommended it to be used on a handkerchief, and to this mistake, must chiefly be attributed the fatal cases that had occurred; for the handkerchief, of course, did not afford any means of regulating the strength of the vapour. Dr. Snow then related the particulars of the fatal cases, which he believed were seven in number—that of Hannah Greener, near Newcastle; that of Mrs. Simmons, in Cincinnati, U.S., which he considered was the only one in which any form of apparatus had been employed, and in that case the dentists who administered the chloroform were not medical men. The remaining cases were a young woman at Hyderabad, a female patient at Boulogne, a young man at Govan, in Scotland, a boy, seventeen years old, at Lyons, and a labouring man recently, in Westminster; he did not include the deaths of two persons from taking chloroform when no one was present, as he was considering only the medical employment of the agent; and he had not included the case of Mr. Badger, who, he considered, did not die from the effects of chloroform—first, because he scarcely inhaled any, the inhaler not having been applied to his face; and secondly, because, according to the evidence of Mr. Robinson and his servant, there were no symptoms either of narcotism or distress, even for a single second, before his death; but his head and hand dropped, and he showed no signs of life afterwards. He considered that the case was one of syncope, through fear either of the operation or of the inhalation, concerning which he had been led to entertain apprehensions, and that the fatty degeneration of the heart under which he suffered rendered the syncope fatal. In nearly all the cases of death from chloroform, the insensibility had been induced within a minute, and in every case, the dangerous symptoms set in very suddenly, proving that the vapour had been inhaled of great strength. In the five cases in which an examination was made after death, there was no particular congestion of the brain, the lungs were greatly congested in two cases, and more or less so in the other three. The cavities of the heart were quite empty in the American case, and in that at Boulogne; but in these instances, strong inflation of the lungs had been practiced for a considerable period after death, and Dr. Sibson had found that the heart became emptied after death, during experiments with artificial respiration in the human subject. In these two cases, air was found in the veins; in that at Boulogne, in the pulmonary as well as the systemic veins. The members of the Académie de Médecine of Paris were inclined to attribute death to this cause, supposing that air could not reach the veins by rupture of the lungs after the left ventricle had ceased to act; but if artificial respiration could empty the heart of blood, it could also press out the air which would reach the left cavities of the heart by minute ruptures of the air-cells, and pulmonary veins, and the arteries possessed the power of expelling their contents into the veins after death, as was proved by their being nearly always found quite empty. The recent case in Westminster showed the uncertainty of the handkerchief in a striking manner, since half an ounce of chloroform was expended in the first instance, without producing insensibility, but little of it getting into the lungs: and then two or three hours afterwards, the same gentlemen, with a similar quantity, not only induced insensibility, but unfortunately administered an over-dose. Whilst he did not wish to blame the persons in whose hands this case had happened, and who had high authority for their method of proceeding, he could not agree in the verdict, that chloroform caused death when it was properly administered. If the vapour were sufficiently diluted with air, and its effects carefully watched, he considered it quite incapable of causing death. At the conclusion of his paper, Dr. Snow performed two experiments on linnets, to show the different effects of vapour of chloroform, according to the quantity of air with which it was diluted. In the first experiment, twelve grains of chloroform were put into a covered glass jar, containing 100 cubic inches, when it was converted into vapour, of which it would form about eight cubic inches, displacing as much air; a bird was introduced; it was quickly affected, and was dead in half a minute. The same quantity of chloroform was then diffused in a similar manner, in a jar holding 600 cubic inches, and another linnet put in; it became gradually insensible, and was removed at the end of about three minutes, and recovered completely in two or three minutes. Dr. Snow said that the vapour required to be rather stronger than this to act as rapidly in larger animals; but that there was the same difference in its effects from a similar difference of strength.

Dr. Sibson said that Dr. Snow had referred to his observations on the mode in which the heart was paralyzed; and on the effect of artificial respiration, by distension of the lungs in emptying the cavities of the heart. It was an ascertained fact, from the history of the cases of death from chloroform, that the heart ceased to beat in those cases at the same time that breathing ceased; and in the late fatal case at Lyons, respiration continued after the cessation of the heart's action. Now the experiments of Mr. Wakley and Dr. Snow had shown that in the lower animals the heart continued to pulsate from one to two minutes after respiration had discontinued. Whence this remarkable difference? Why is it that in man, under chloroform, the heart's action should usually cease before respiration, while in the lower animal respiration should usually cease before the heart's action? This question it was difficult, but, in a therapeutical point of view, important to answer. Opium, in poisonous doses, excited in the lower animals constant tetanic contractions; but it did not do so in man. This difference was clearly due to the superior control exercised by the brain, by the mind of man over the reflex or spinal actions, his brain having a higher development, a greater controlling power, than the brain of any lower animal. Could the sudden action of chloroform on the heart of man be accounted for, physiologically, in the same way? Influenced by sudden mental depression, a woman will fall into syncope, pallid and pulseless, to the ground; the heart's action suddenly ceases under the sudden influence of the mind. A French writer has recently suggested that syncope, the sudden cessation of consciousness, may be the cause of the sudden cessation of the heart's action under chloroform. It appeared to the speaker that this view was supported by physiological analogies. Another mode in which the action of the heart might be destroyed, was the production of paralysis of the heart by the immediate action of the chloroform on its fibres, the chloroform (as he had stated in a paper, from which Dr. Snow had quoted) being sent more rapidly, and in greater concentration, to the muscular fibres of the heart, than to any other part of the body, the lungs excepted. This view, which had much to recommend it, was in some measure opposed by the fact that the heart's action continued after breathing had ceased in the lower animals. From the valuable observations of Dr. Snow, it appeared, however, that sometimes, even in the lower animals, the heart's action ceased with respiration. This, however, may be due to the *third* way in which the heart's action may be arrested by the action of chloroform. Dr. Whytt found that under the action of opium the heart ceased, the right cavities being excessively distended. On lessening the blood in the cavities, the heart resumed its action. Sir B. Brodie observed the same phenomena under the action of tobacco, and he kept up the renewed heart's action by artificial respiration. Drs. Reid, Cormack, and Lonsdale have made similar observations in animals poisoned by creasote and prussic acid. In these cases the heart's action has not been arrested by paralysis of its muscular fibre, but by overwork; it has had more blood in it than it could send out, and more resistance to overcome, in the pulmonic capillaries, (for there is resistance to the circulation in both pulmonic and systemic capillaries, under the action of narcotics and of asphyxia,) than it was capable of overcoming. As yet, we had had no opportunity of deciding, by post-mortem examination, whether the death of the heart had been occasioned in either of the two last methods, as in all the cases artificial respiration, by inflation of the lungs, had been performed, and thus the blood had been expelled from the cavities of the heart. In all the cases, the heart's cavities were empty, or nearly so; and that this was due to the artificial inflation of the lungs, was proved by the speaker's experiments, referred to by Dr. Snow. In constructing diagrams of the position of the ribs and internal viscera, he first took a diagram before the inflation of the lungs, and then another after inflating the lungs to the full, and he always found that, unless the vena cava was tied, the heart was nearly emptied by the inflation: this was due to the pressure exerted by the expanded ribs on the distended lungs, which in their turn pressed upon the heart, and which was also compressed by the sternum and the diaphragm. Dr. Sibson considered that artificial respiration by inflation was inadmissible in these cases, for the reasons just stated; still less was M. Ray's plan admissible, by the alternate compression and relaxation of the chest and abdomen by a many-tailed bandage; as, under the abdominal pressure, the contents of the stomach would be pressed out through the cardiac orifice, ascend the œsophagus to the pharynx, and regurgitate into the larynx and trachea, the vocal cords being paralyzed. He had contrived a plan of performing artificial respiration, which had been suggested to him in a case of poisoning by opium, in which Dr. Gaskell had performed artificial respiration by placing plasters over the ribs, and, through their means, by drawing upon and expanding the walls of the chest from without, somewhat on the principle of the boy's leather sucker. The speaker had a leaden breastplate made, with the handle; this was covered with an adhesive substance, welted caoutchouc, and was thus made to adhere to the skin over the sternum; on drawing this forward, the chest was somewhat expanded, while on pressing it back, some air was expelled from the lungs; and so, by alternate suction and pressure, an artificial respiration was kept up without inflating the lungs. The amount of air so taken into the lungs was inconsiderable, but probably enough for the purpose, should artificial respiration be required for persons under the extreme action of chloroform.

Mr. Gream would still contend that there was much uncertainty respecting the action of chloroform, and the deaths and casualties attending its administration proved this. Notwithstanding the experiments on animals, as Dr. Sibson had observed, the effects on the human subject were different. Dr. Snow had objected to the case of Mr. Badger being one of death from chloroform; but he would ask—Would Mr. Badger, or the other persons objected to by Dr. Snow, have died unless chloroform had been used? Mr. Gream proceeded to rectify some mistakes into which he considered Dr. Snow had fallen, with respect to the detail of some of the cases, and contended that the death in every case was due to ether or chloroform. He particularly alluded to the fact of Mr. Badger having been in good spirits immediately before his death: this was evidenced by his saying the chloroform was not strong enough, and requesting to be supplied with more. Now, he (Mr. Gream) contended that Mr. Badger had then inhaled sufficient to kill him, but the effects of the medicine developed themselves suddenly, and showed the danger and uncertainty attending its administration. Mr. Gream then mentioned several cases of deaths from chloroform or ether, and death from either of these agents was the same in regard to the arguments adduced by Dr. Snow. Among these cases, he mentioned an instance of the removal of some glandular swellings from the axilla of a woman who insisted upon inhaling chloroform. She died immediately. He related another case, lately reported in *The Lancet*, as having occurred at the Hôpital Beaujon, of death immediately after amputation of the thigh, in which chloroform was used. He related some other fatal cases; two, in which convulsions took place: one continuing twenty-four hours; the other, three hours; in the case of a lady with twins, chloroform was administered with the last child; the woman died in half an hour. A case of operation at Birkenhead; death in half an hour. He contended that harm was done by telling the profession and the public that no danger attended the use of chloroform. He was in favour of its use in operative surgery, in which it had been employed in thousands of cases, and in which, if it had destroyed two or three lives, it had saved hundreds; but he did protest against its use in cases of natural labour. It was wrong to give it to women who would not die without it. Mr. Gream then detailed a great number of cases in which its use had been attended with fatal or disastrous results, when given either to relieve the pain of labour, or for other purposes.—*Lancet*, April 14, 1849.